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(71) Applicant
Pilkington P.E. Limited (United Kingdom),
Prescot Road, St Helens, Merseyside WA10 3TT

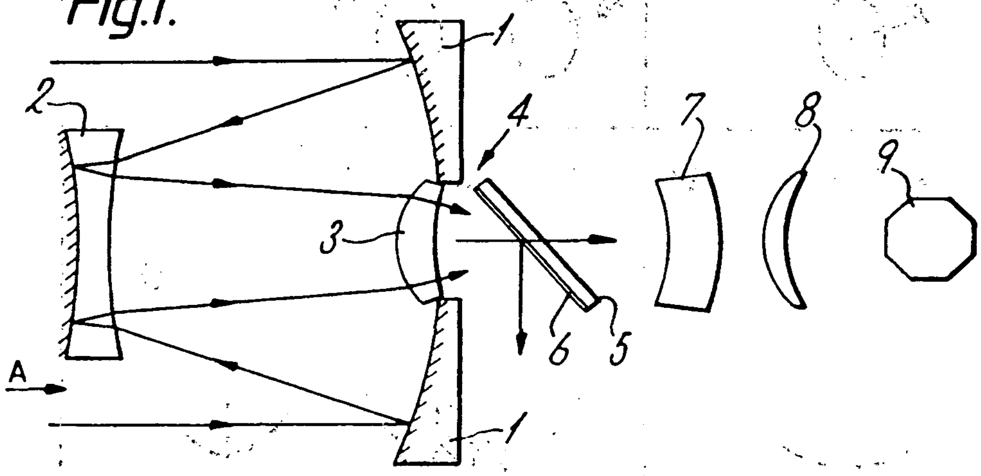
(72) Inventor
Philip John Rogers

(74) Agent and/or Address for Service
R A Bride,
Pilkington Brothers P.L.C, Group Patents Department,
Prescot Road, St Helens, Merseyside WA10 3TT

(54) Optical apparatus for transmitting, and splitting infra-red and visible radiation

(57) A compact optical apparatus comprises a self-achromatised catadioptric lens system (1,2,3,4) whose refractive elements (2,3) transmit both infra-red and visible radiation and a beam splitter (5,6) which transmits the infra-red radiation to a collimator (7,8) and scanner (9) but reflects the visible radiation into two visible light channels (Fig. 2 not shown). The infra-red radiation can be used to produce a thermal picture of the viewed scene and the visible light channels can be visual channels providing a stereoscopic view, or one can be visual and the other for transmitting and/or receiving a laser beam. The apparatus may be used in a battle tank.

Fig.1.



GB 2 158 261 A

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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Fig.1.

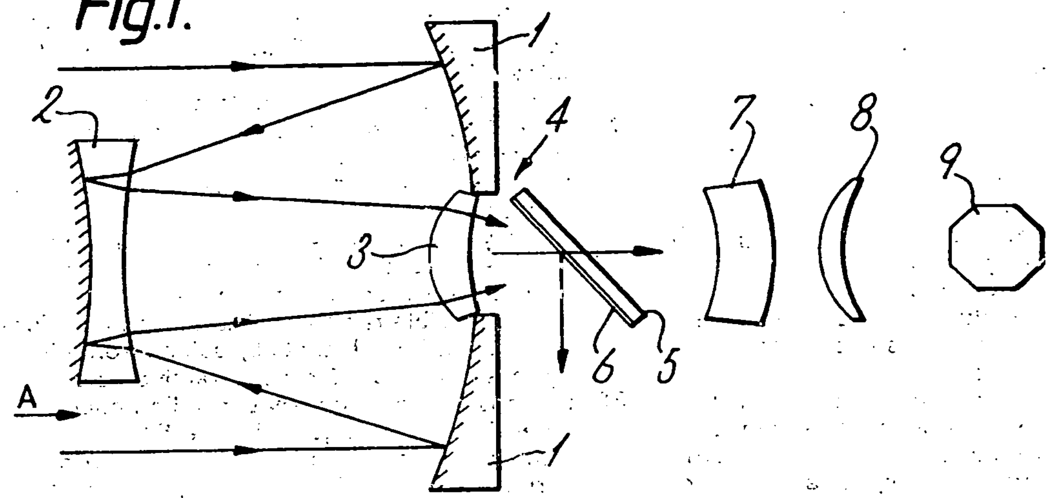
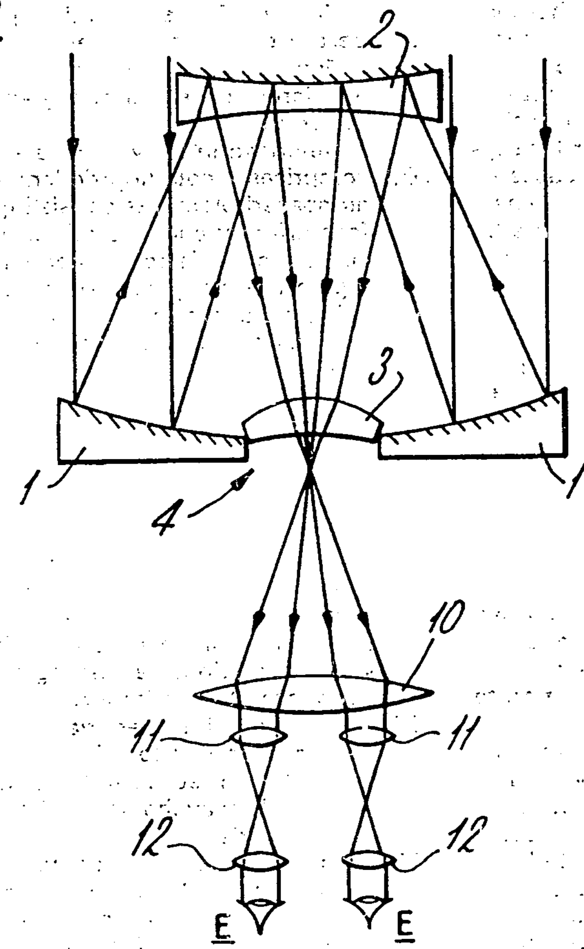


Fig.2.



SPECIFICATION

Improv ments in or relating to optical apparatus

This invention concerns improvements in or relating to optical apparatus and relates more particularly to optical apparatus operable with both infra-red and visible radiation.

In some circumstances, and especially in the military field, there is a continuing requirement for versatile operational capability but with severe restrictions on the space which can be occupied by equipment providing such versatility. For example, an armoured vehicle such as a battle tank may be required to provide a thermal picture from received infra-red radiation, e.g. for night surveillance, and to use received visible radiation for a day sight, which may be stereoscopic, or which may be non-stereoscopic with a laser rangefinder which transmits and receives on return a laser beam. However, the space available in the vehicle to accommodate equipment for providing these facilities may be very limited. There is thus a requirement for compact and versatile optical apparatus for use in such equipment.

According to the present invention there is provided optical apparatus comprising a substantially self-achromatised catadioptric lens system having refractive elements of a material transmissive to both infra-red and visible radiation, a wavelength selective filter for separating infra-red and visible radiation passed through the catadioptric lens system, means for receiving infra-red radiation so separated, and means providing two spaced light channels for receiving visible radiation so separated.

The two spaced light channels may constitute visual channels for providing an observer with a stereoscopic view of a scene or object from which visible light is received by the catadioptric lens system. Alternatively one of the light channels may constitute a visual channel for viewing of such scene or object and the other light channel may constitute a laser channel for transmitting and/or receiving a laser beam. There may be provided a telescope comprising an objective lens and an eyepiece lens in the or each visual channel. There may be a lens element, such as a collimating element, spanning and common to both light channels.

The means for receiving infra-red radiation may comprise a collimator, which may pass the radiation to a scanner device. The infra-red radiation may be in the thermal waveband and the scanner device with an associated detector array may be used to produce a thermal picture of a scene or object from which such infra-red radiation is received by the catadioptric lens system.

The wavelength selective filter may comprise a beam splitter which separates the infra-red and visible radiation by transmission of one and reflection of the other. For example, the beam splitter may comprise a plate of infra-red transmissive material having a dichroic coating on its front surface which reflects the visible radiation but transmits the infra-red.

The catadioptric lens system preferably comprises a front surface primary concave mirror having a central aperture, a Mangin secondary mirror, and at least one correction element located at or near the aperture in the primary mirror, the Mangin secondary mirror and the correction element or elements being of material which is transmissive to both infra-red and visible radiation. The catadioptric lens system can be substantially self-achromatised by reason of the effective refractive powers of the lens elements largely cancelling each other. The wavelength selective filter may be located at or near the aperture in the primary mirror of the catadioptric lens system to receive radiation passed through that aperture.

An embodiment of optical apparatus in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of part of the apparatus, and

Figure 2 is a schematic representation from a different aspect showing another part of the apparatus.

Referring initially to Figure 1, the apparatus comprises a catadioptric lens system having air spaced elements consisting of a front surface primary concave mirror 1 of spherical curvature, a Mangin secondary mirror 2 having an internally convex reflecting surface of spherical curvature, and a positive meniscus correction element 3 having its convex surface facing towards the Mangin secondary mirror 2. The primary mirror 1 has a central aperture 4 at or near which the correction element 3 is located. A catadioptric lens system of this form is more fully described in U.K. Patent GB 2 030 315B, the relevant teachings of which are incorporated herein by reference. In the present embodiment however, the refractive lens elements, i.e. the Mangin secondary mirror 2 and the correction element 3, are of a material transmissive to both infra-red and visible radiation, i.e. having a useful spectral bandpass at both infra-red and visible wavelengths. The infra-red waveband may in particular be about 8 to 14 microns, i.e. the thermal infra-red. A suitable material for this and visible wavebands is visually transmissive zinc sulphide.

As described in the above mentioned U.K. Patent GB 2 030 315B, the catadioptric lens system can be substantially self-achromatised by reason of the effective refractive powers of the lens elements largely cancelling each other. The expression 'substantially self-achro-

matised' when used herein is not to be construed as limited to absolute self-achromatisation but includes in particular a system which is almost self-achromatised. It is also to be understood that, as mentioned in U.K. Patent GB 2 030 315B, the catadioptric lens system may include more than one correction lens element 3 if required.

The catadioptric lens system of the present embodiment is substantially self-achromatised so that, in use, it receives thermal infra-red and visible radiation and focusses the wavebands of both. Specifically the received radiation is reflected from the primary mirror 1, refracted on entry into and exit from the Mangin secondary mirror 2 in which it is reflected, and refracted as it is transmitted through the correction element 3 to form an image in the region of the aperture 4 through which the radiation passes.

At or near the aperture 4 is a wavelength selective filter in the form of a beam splitter comprising a plate 5 of infra-red transmissive material, such as germanium, having on its front face a dichroic coating 6 which reflects visible radiation but transmits infra-red. The beam splitter thus separates infra-red and visible radiation passed through the catadioptric lens system into respective channels. It will be appreciated that the beam splitter could alternatively be arranged to reflect the infra-red and transmit the visible, in which case the infra-red and visible channels about to be described would be transposed.

As shown in Figure 1, infra red radiation is transmitted through the beam splitter plate 5 to the infra-red channel where it is received by a collimator comprising elements, shown as 7 and 8, of infra-red transmissive material, such as germanium. This collimator may, for example be of a form as described in U.K. Patent No. 1594966, but other forms, which may have more than two elements, could be used. The asymmetric aberrations introduced by the beam splitter can be corrected by introducing asymmetry into the collimator, or associated optics, design. The collimated infra-red radiation passes to a scanner 9 by which it is scanned across an infra-red detector array to produce in known manner a thermal picture of the scene or object from which thermal infra-red radiation is received by the catadioptric lens system. Visible radiation reflected by the beam splitter coating 6 passes to visible light channels not shown in Figure 1 but shown in Figure 2, which is a view from the direction indicated by arrow A in Figure 1 but with the system shown in straightened form (i.e. with the beam splitter in effect omitted) for ease of illustration. A collimating lens element 10 receives (in fact after reflection from the beam splitter) the visible light passed through the central aperture 4 of the catadioptric lens system. As can be seen from Figure 2, the catadioptric lens form, with its central obscuration of the incident radiation, is inherently adapted to direct the light into two spaced channels which respectively receive light incident on the primary mirror 1 at opposite sides of the central obscuration caused by the Mangin secondary mirror 2. In Figure 2 the two spaced visible light channels are represented as constituting visual channels, there being a telescope comprising an objective lens 11 and an eyepiece lens 12 in each channel. The collimating lens 10 spans and is common to both channels. An observer viewing with his two eyes E along the respective visual channels can see the scene or object from which visible light is received by the catadioptric lens system, and can obtain a stereoscopic view by reason of the effectively separated light receiving positions on opposite sides of the central obscuration mentioned above.

Instead of using the two visible light channels as visual channels to provide a stereoscopic view, one only could be used as a visual channel providing a non-stereoscopic view and the other could constitute a laser channel for transmitting and/or receiving a laser beam. Such laser channel could be used for laser range finding purposes, the laser beam being for example from a Neodymium-YAG laser. Suitable filters can be provided, if necessary, to prevent laser light entering the visual channel.

It will be appreciated that the infra-red and visible light channels need not necessarily, although they may, be simultaneously used operationally. Thus, the infra-red channel may be used at night or under other low visibility conditions to provide a thermal sight, while the visual channel or channels may be used during the day, or under other illumination conditions providing adequate visibility, as a visible light sight, commonly called a day sight.

It will be seen that the apparatus, in having a common objective lens system for infra-red and visible radiation, can be compact whilst providing the versatility of infra-red and visible light operation, and in having two separate visible light channels can provide increased versatility by way of stereoscopic viewing or by way of a visual channel and a laser channel. The apparatus can therefore be usefully applied in limited space situations requiring versatility of operation as can occur, for example, in an armoured vehicle such as a battle tank.

CLAIMS

1. Optical apparatus comprising a substantially self-achromatised catadioptric lens system having refractive elements of a material transmissive to both infra-red and visible radiation, a wavelength selective filter for separating infra-red and visible radiation passed through the catadioptric lens system, means

for receiving infra-red radiation so separated, and means providing two spaced light channels for receiving visible radiation so separated.

2. Apparatus according to Claim 1 in which the two spaced light channels constitute visual channels for providing an observer with a stereoscopic view of a scene or object from which visible light is received by the catadioptric lens system.

3. Apparatus according to Claim 1 in which one of the light channels constitutes a visual channel for viewing a scene or object from which visible light is received by the catadioptric lens system and the other light channel constitutes a laser channel for transmitting and/or receiving a laser beam.

4. Apparatus according to Claim 2 or Claim 3 having a telescope comprising an objective lens and an eyepiece lens in the or each visual channel.

5. Apparatus according to any preceding claim comprising a lens element spanning and common to both light channels.

6. Apparatus according to Claim 5 in which said lens element is a collimating element.

7. Apparatus according to any preceding claim in which the means for receiving infra-red radiation comprises a collimator.

8. Apparatus according to Claim 7 in which the collimator passes the radiation to a scanner device.

9. Apparatus according to Claim 8 in which the scanner device with an associated detector array is used to produce a thermal picture of a scene or object from which infra-red radiation in the thermal waveband is received by the catadioptric lens system.

10. Apparatus according to any preceding claim in which the wavelength selective filter comprises a beam splitter which separates the infra-red and visible radiation by transmission of one and reflection of the other.

11. Apparatus according to Claim 10 in which the beam splitter comprises a plate of infra-red transmissive material having a dichroic coating on its front surface which reflects the visible radiation but transmits the infra-red.

12. Apparatus according to any preceding claim in which the catadioptric lens system comprises a front surface primary concave mirror having a central aperture, a Mangin secondary mirror, and at least one correction element located at or near the aperture in the primary mirror, the Mangin secondary mirror and the correction element or elements being of material which is transmissive to both infra-red and visible radiation.

13. Apparatus according to any preceding claim in which the wavelength selective filter is located at or near the aperture in the primary mirror of the catadioptric lens system to receive radiation passed through that aperture.

14. Optical apparatus substantially as described herein with reference to the accompanying drawings.

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